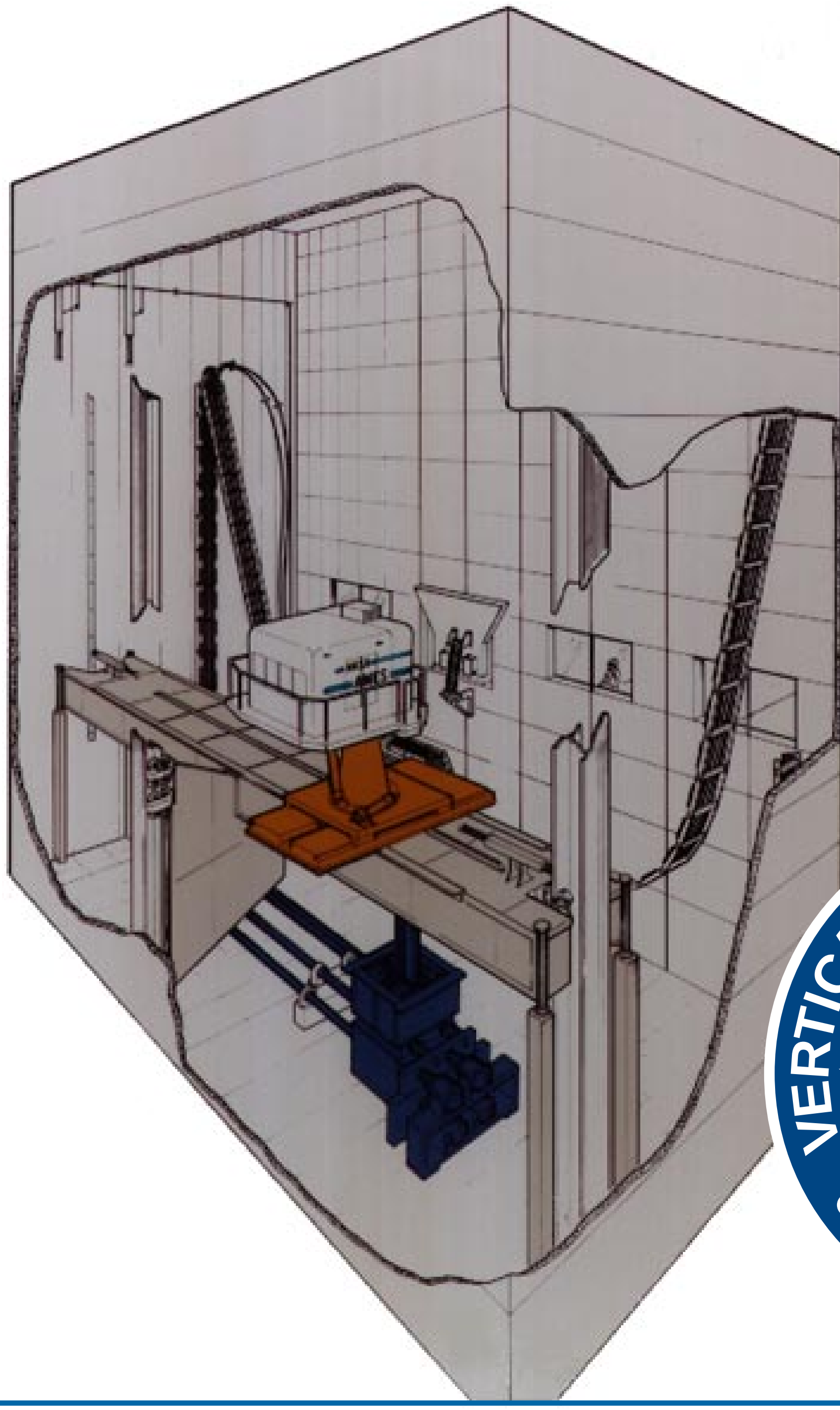
# SIMLAB YEAR IN REVIEW
## FY 1994



VERTICAL MOTION SIMULATOR
NASA-AMES

# INTRODUCTION

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This is the Fiscal Year (FY) 1994 Annual Report, the NASA-Ames Vertical Motion Simulation Laboratory Facility (SimLab), Aeronautical Test and Simulation Division. This document is intended to report to our customers and management on the more significant SimLab events of FY94. What follows is a summary of the simulation investigations conducted in the facilities during the year, a projection of work for FY95, and a summary of Simulation Technology Update Projects.

The reader is referred to a complementary document, entitled "Ames Research Center, SimLab," for a brief discussion of the SimLab facilities and its capabilities for supporting aeronautical research and enhancing flight simulation technology.

Aeronautical Test and Simulation Division
NASA/Ames Research Center
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1 December 1994

# SIMLAB ACTIVITIES - FY94
# EXECUTIVE SUMMARY

Fiscal Year 1994 was one of organizational transition with a renewed focus on relevance to NASA mission objectives and an operational reaffirmation to providing highly responsive, cost-effective, value-added simulation support to all of our customers. Effective customer communication at all levels and emerging technology enhancements remain as exceedingly important and continuing strategic objectives.

SimLab is committed to uncommon excellence in the development and production of efficient, real-time, high fidelity, large amplitude motion-based, piloted flight simulations. We have and will continue to aggressively pursue and selectively invest in the enabling simulation and computational technologies to maintain our competitive edge and be second to no other simulation facility worldwide.

Notable accomplishments for FY94 include the following:

A. Fifteen major simulation experiments were conducted in the Vertical Motion Simulator (VMS) Facility. This is an increase in simulations over the previous year, *accomplished with a lesser number of overall staff resources.*

B. SimLab is approaching the final stages of the operations/funding strategy developed in FY90. Some computer upgrades were accomplished during the year.

C. The Evans & Sutherland ESIG-3000 Computer Generated Imagery system was installed, integrated, tested, and put into operation. The first operational use of the ESIG-3000 supported the Space Shuttle.

D. The Advanced Simulator Network (ASN) Project made substantial progress and nearly completed the prototype phase. This consisted of acquiring the prototype hardware, developing the real-time software, and validating the capability of the overall system for SimLab operational usage.

E. SimLab impaneled a Continuous Improvement Steering Committee to identify, study and restructure processes that would lead to substantive SimLab savings, once implemented. The Steering Committee established five Process Action Teams (PATs) and made recommendations for change.

a. SimLab developed and conducted 15 major simulation experiments using the VMS, the world's largest motion-based simulator. The increase in productivity results from facility improvements, enhanced training and capability upgrades made in previous years, and SimLab's on-going continuous improvement activities noted below.

The simulations and the respective principal customers are shown in the table below. The projects reflect a concentration on NASA's focused programs: High Speed Research (High Speed Civil Transport - HSCT), Advanced Subsonic Transport/Short-Haul Civil Transport (Civil TiltRotor - CTR), Common Affordable Lightweight Fighter (Advanced Short Take Off Vertical Landing - ASTOVL), and Space Operations (Space Shuttle Orbiter).

| PROJECT | CUSTOMER(S) |
|---:|---|
| HSCT (four entries) | Boeing, Douglas, NASA HSRPO |
| Civil TiltRotor | FAA, Industry, NASA |
| ASTOVL (two entries) | Industry |
| HELMEE 2 | Army |
| ESIG Integration | overall facility enhancement |
| Space Shuttle (two entries) | Rockwell/NASA JSC |
| CATAPOD | FAA/Industry/NASA |
| GERMOU | Army |
| SORBET | overall facility enhancement |
| BLIMP | Westinghouse/Navy |

b. The five-year plan (operations/funding strategy) developed in FY90 has been extremely successful in enhancing facility capabilities and is nearing completion. The VAX 4000 was upgraded to a VAX 4000-200. It now has the speed of the VAX 6000, at a significantly reduced cost. A new SGI IRIS was added to the compliment of cockpit graphics generators. The ESIG-3000, detailed below, was also a part of the FY90 five-year plan.

The building cooling system for N243 underwent a major modification in FY94. A thermal storage system was installed that conserves energy, reduces costs, and adds redundancy to the building's cooling system. A chiller is run at maximum efficiency during the night when rates are lowest and freezes water (with additives) in storage tanks. During the day, water is recycled through the storage tanks to provide cooling for the building.

c. The JSC/Shuttle Project Office funded Evans & Sutherland ESIG-3000 Computer Generated Imagery (CGI) system was installed, integrated, tested, and put into operation. The ESIG delivers greatly enhanced visual scene fidelity and capability, specifically in the areas of texture, terrain, moving models, and animation. Pilots have commented repeatedly that the simulation fidelity has been greatly enhanced by increased quality of the out-the-window scene.

The ESIG-3000 was fully integrated into SimLab in a mere four months from delivery to on-line operation, with the entire integration developed and implemented by a team of on-site contract support and civil service personnel. SimLab is the first known use of a direct Ethernet/Host interface for ESIG-3000 and the first know integration of both round and flat earth real-time systems for production simulation.

The first use of the ESIG-3000 was the Space Shuttle. It was an unqualified success as SimLab operations were flawless. Some of the technical improvements include the following.

- The increased number of polygons makes the scene much more realistic to the pilots and greatly enhanced their sense of “ground rush” which is important during the landing and rollout phase of the flight.

- The increase in scene realism was such that pilots have commented that the visuals were easier on the eyes and they could fly longer with it.

- The display of lights and light groups is a quantum leap above previous CGIs. The lights can now be seen brightly from distances and close proximity giving the pilots the ability to fly landings without a HUD, which they could not with the previous visuals.

- The time delays were reduced, thereby increasing the fidelity of the simulation.

- Because runways are moving models and not separate databases, changing runway scenes can be done on-line and does not require an operator’s intervention to change the database. This increase in efficiency saved the project a minimum of 30 minutes a day.

- With the increased number of channels, the commander and pilot can each have an eye point, thereby adding to the realism of the simulation.

- Initial conditions for flights can be at vehicle altitudes of 50,000 feet and above and still have a realistic scene. The previous IG displayed only the horizon line.

Importantly, as with previous CGI systems, SimLab has the capability to develop visual databases for the ESIG-3000. The first ESIG database project resulted in a high fidelity representation of the San Francisco Bay area. It extends from the top of the north bay to just south of San Jose and from 10 miles out in the Pacific eastward to the San Ramon Valley. There are three Vertiport sites with approach lighting systems. There are three runway systems including San Francisco, Oakland, and Treasure Island NAS. This new database is fully operational.

d. Substantive progress was made on the Advanced Simulator Network (ASN) Project. The prototype system hardware was assembled and the simulation executive software from the currently used hosts was partially ported to the prototype host. The host, a Digital Equipment Co./Alpha workstation, was acquired for testing and evaluation. The network of distributed ADs and DAs is a Kinetic Systems CAMAC system. Tests of the network were performed in stand-alone and in diagnostics modes from the host. Upon completion of the simulation executive software port, evaluation of the prototype system will begin.

e. SimLab remains aggressive in its Continuous Improvement program, and has been so for several years. Five Process Action Teams (PATs) studied different internal SimLab processes and made recommendations for change, most of which are currently being implemented. The areas acted upon were SimLab procurement, administration and documentation, I-CAB build-up and checkout, personal computer hardware and software, and the cab visual alignment process.

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## Some Future Plans:

- The ASN Project will continue with its plans in FY95. After completing the prototype effort, the next phase is integration. The first simulation facilities to be integrated will be the fixed-base lab and a cab. Integration with the Vertical Motion Simulator and remaining fixed-base facilities will follow.

- Due to the recent Ames reorganization, SimLab (the entire VMS/N243 complex) is now combined with the Crew Vehicle Simulation Research Facility (CVSRF, N257). Both are grouped with certain wind tunnel test facilities to form the new Aeronautical Test and Simulation Division (AO). The division and its resources are dedicated to support efficiently the nation's R&D development and on-going aircraft/aerospace programs encompassing all aircraft types and flight regimes. Facility enhancements and technology investments will continue to ensure the competitive advantage of our facilities that are critical to the conduct of aeronautical research for our many commercial, international, military and NASA customers.

  We will continue our tradition of supporting mainstream NASA and national aeronautical development programs being second to none in state-of-the-art real-time simulation and enabling technologies. Automated tools for simulation and modeling, improvements in graphics and displays and efficient computational environments are continuing efforts.

# PROJECTED WORK

The schedule emphasizes our continuing focus on simulation support of NASA's mainstream projects in rotorcraft, future commercial transports, STOVL technology and SSV touchdown handling qualities. Technical upgrades are part of SimLab's strategic investments to continually improve our facility capabilities (hardware, software, and staff resources) so as to more efficiently serve our overall customer base.

# FY95 SCHEDULE
# VMS/I-CAB SIMULATIONS

| Project | Simulation | Description |
|---|---|---|
| BLIMP | BLIMP | HANDLING QUALITIES EVALUATION OF THE YEZ-2A AIRSHIP |
| CTR5 | CIVIL TILTROTOR | INVESTIGATION INTO VERTIPORT DESIGN, TERMINAL OPERATIONS & CERTIFICATION ISSUES FOR TILTROTOR A/C |
| XV-15 | XV-15 | PILOT FAMILIARIZATION BEFORE XV-15 RETURN TO FLIGHT |
| MOUSE | MOTION UPGRADE | MOTION OPERATIONS & UNIVERSAL SIMULATION ENHANCEMENTS |
| SSV -1 '95 | ORBITER | LANDING & ROLLOUT STUDIES, & ASTRONAUT TRAINING |
| HELMEE 3 | UH-60 | INVESTIGATION OF HELICOPTER FLIGHT ENVELOPE LIMITS & PILOT CUEING SYSTEMS |
| SLUNG LOAD | ESD/ROTORGEN | SCAS DESIGNS TO IMPROVE HANDLING QUALITIES FOR CARGO-CLASS HELICOPTERS |
| ANOE 3 | UH-60 | AUTOMATED NAP-OF-THE-EARTH HELICOPTER FLIGHT RESEARCH |
| ASTOVL-GC | STOVL | INVESTIGATION OF INTEGRATED FLIGHT & PROPULSION CONTROLS, & HUDS (FIXED-BASE) |
| MOUSE | MOTION UPGRADE | MOTION OPERATIONS & UNIVERSAL SIMULATION ENHANCEMENTS |
| HSCT 1 | HSCT | INVESTIGATION INTO HANDLING QUALITIES (FIXED-BASE) |
| CATAPOD 2 | UH-60 | DESIGN & EVALUATION OF DISLAYS FOR HELICOPTER TAKEOFFS & LANDINGS |
| SSV-2 '95 | ORBITER | LANDING & ROLLOUT STUDIES, & ASTRONAUT TRAINING |
| ASTOVL | STOVL | INVESTIGATION OF INTEGRATED FLIGHT & PROPULSION CONTROLS, & HUDS |

Timeline (week columns): Oct '94: 3, 10, 17, 24, 31; Nov '94: 7, 14, 21, 28; Dec '94: 5, 12, 19, 26; Jan '95: 2, 9, 16, 23, 30; Feb '95: 6, 13, 20, 27; Mar '95: 6, 13, 20, 27; Apr '95: 3, 10, 17, 24; May '95: 1, 8, 15, 22, 29; Jun '95: 5, 12, 19, 26; Jul '95: 3, 10, 17, 24, 31; Aug '95: 7, 14, 21, 28; Sep '95: 4, 11, 18, 25

# FY94 SCHEDULE
# VMS/I-CAB SIMULATIONS

Oct '93 – Sep '94 (weeks: Oct '93: 4, 11, 18, 25; Nov '93: 1, 8, 15, 22, 29; Dec '93: 6, 13, 20, 27; Jan '94: 3, 10, 17, 24, 31; Feb '94: 7, 14, 21, 28; Mar '94: 7, 14, 21, 28; Apr '94: 4, 11, 18, 25; May '94: 2, 9, 16, 23, 30; Jun '94: 6, 13, 20, 27; Jul '94: 4, 11, 18, 25; Aug '94: 1, 8, 15, 22, 29; Sep '94: 5, 12, 19, 26)

| Project | Simulation | Description |
|---|---|---|
| HSCT-D 1 | HSCT | HANDLING QUALITIES INVESTIGATIONS OF DOUGLAS HIGH SPEED CIVIL TRANSPORT CONCEPTS |
| HSCT-B 1 | HSCT | HANDLING QUALITIES INVESTIGATIONS OF BOEING HIGH SPEED CIVIL TRANSPORT CONCEPTS |
| CTR4 | CIVIL TILTROTOR | INTEGRATION OF TILTROTOR AC INTO CIVIL OPERATION<br>INVESTIGATION OF MISSED APPROACH & DEPARTURE GUIDANCE |
| ASTOVL-C | (FIXED-BASE) STOVL | RESEARCH INTO FLIGHT & PROPULSION CONTROLS & HUDS FOR STOVL CONCEPTS |
| HELMEE 2 | UH-60 | INVESTIGATION OF HELICPOTER FLIGHT ENVELOPE LIMITS & PILOT CUEING SYSTEMS |
| CTR4.5 (ESIG-3000 TEST) | (FIXED-BASE) CTR | OPERATIONAL TEST OF INTEGRATED ESIG-3000 COMPUTER GENERATED IMAGERY SYSTEM |
| SSV-1 | ORBITER | DRAG CHUTE/DEROTATION, TIRE LOADS, & CREW TRAINING |
| CATAPOD | UH-60 | DESIGN & EVALUATION OF DISPLAY LAWS & FORMATS FOR<br>HELICOPTER TAKEOFFS & LANDINGS IN CONFINED AREAS |
| GERMOU | GEN HELICOPTER | INVESTIGATION OF HELICOPTER HANDING QUALITIES |
| SORBET | UH-60 | INVESTIGATION OF BLADE-ELEMENT<br>TURBULENCE ON HELICOPTER FLIGHT DYNAMICS |
| HSCT-D 2 | HSCT | HANDLING QUALITIES INVESTIGATIONS OF DOUGLAS<br>HIGH SPEED CIVIL TRANSPORT CONCEPTS |
| HSCT-B 2 | HSCT | HANDLING QUALITIES INVESTIGATIONS OF BOEING<br>HIGH SPEED CIVIL TRANSPORT CONCEPTS |
| ASTOVL-LF | STOVL | FIXED & MOTION BASED RESEARCH INTO FLIGHT & PROPULSION<br>CONTROLS & HEAD-UP DISPLAYS FOR STOVL CONCEPTS |
| SSV-2 | ORBITER | DRAG CHUTE/DEROTATION, TIRE LOADS, & CREW TRAINING |
| BLIMP | BLIMP | HANDLING QUALITIES EVALUATION OF YEZ-2A AIRSHIP |

## Simulation Projects

1. HSCT-D 1 4 OCT - 28 OCT (4 wks)
Aircraft type: generic, large transport
Purpose: To evaluate descent, approach, landing and go-arounds with an aircraft of a weight class similar to the Douglas proposal for the High Speed Civil Transport (HSCT). Evaluate controls, HUDs, and HDDs.

2. HSCT-B 1 1 NOV - 5 NOV (1 wk)
Aircraft type: Boeing High-Speed Civil Transport design
Purpose: To evaluate descent, approach, landing and go-arounds with the Boeing design, proposed for the HSCT. Evaluate controls, HUDs, and HDDs.

3. CTR4 8 NOV - 17 DEC (6 wks)
Vehicle type: generic tiltrotor
Purpose: To refine terminal area operations for the Civil TiltRotor.

4. ASTOVL-C 15 NOV - 17 DEC (5 wks)
Aircraft type: Short Take-Off/Vertical Landing (STOVL) fighter
Purpose: To evaluate STOVL flight control systems.

5. HELMEE 2 3 JAN - 4 FEB (5 wks)
Aircraft type: UH-60 Black Hawk helicopter
Purpose: To develop insight into the issues associated with helicopter maneuver limiting and cueing.

6. CTR4.5 (ESIG-3000 TEST) 3 JAN - 21 JAN (3 wks)
Aircraft type: generic tiltrotor
Purpose: To test the new ESIG-3000 image generator system for operational readiness. Also provide additional research time for CTR.

7. SSV-1 7 FEB - 18 MAR (6 wks)
Aircraft type: Space Shuttle orbiter
Purpose: To continue research into drag chute handling qualities, pilot workload measurements, and continued crew training.

8. CATAPOD 21 MAR - 22 APR (5 wks)
Aircraft type: UH-60 Black Hawk helicopter
Purpose: To investigate the effectiveness of panel-mounted displays during Category A terminal area procedures.

9. GERMOU 18 APR - 29 APR (2 wks)
Aircraft type: generic helicopter model
Purpose: To investigate helicopter handling qualities.

10. SORBET 25 APR -13 MAY (3 wks)
Aircraft type: UH-60 Black Hawk helicopter
Purpose: To evaluate a new blade element turbulence simulation model.

11. HSCT-D 2 16 MAY - 10 JUN (4 wks)
Aircraft type: Douglas HSCT and generic large transport
Purpose: To investigate the flying qualities during approach and landing of two different aircraft: the High Speed Civil Transport (HSCT) and an augmented, generic large transport (GLT).

12. HSCT-B 2 13 JUN - 8 JUL (4 wks)
Aircraft type: Boeing HSCT
Purpose: To refine and operationally extend the controls and displays of the aircraft.

13. ASTOVL-LF 27 JUN - 12 AUG (7 wks)
Aircraft type: Short Take-Off/Vertical Landing (STOVL) fighter
Purpose: To develop a STOVL fighter that will work for both land-based and ship-based operations.

14. SSV-2 15 AUG - 23 SEPT (6 wks)
Aircraft type: Space Shuttle orbiter
Purpose: To investigate lateral handling qualities of the Orbiter on the runway, guidance improvements during landing, and provide astronaut training.

15. BLIMP 26 SEPT - 27 OCT (5 wks)
Aircraft type: YEZ-2A airship
Purpose: To evaluate handling qualities of an airship during refueling and resupply from a surface ship.

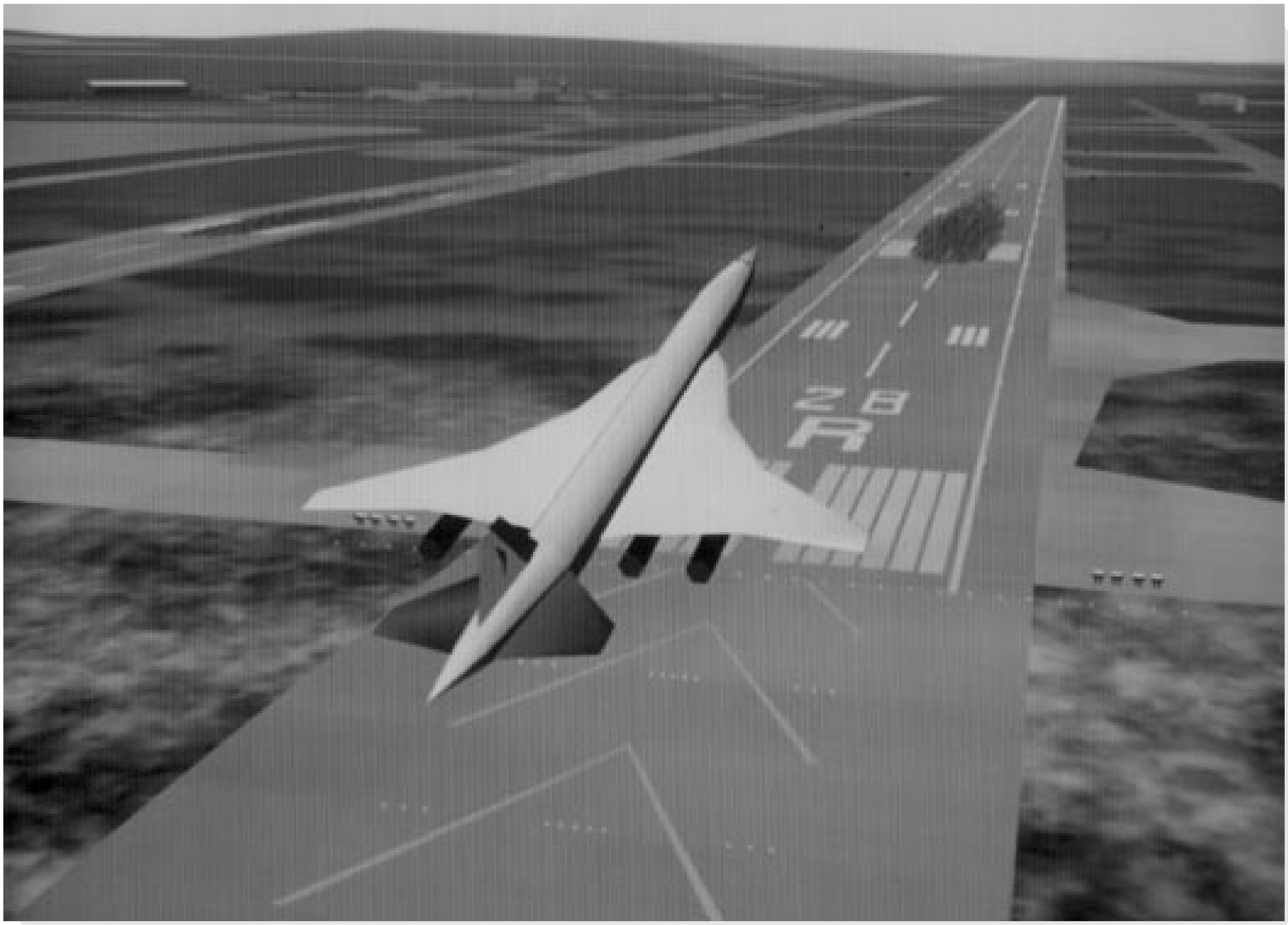
## Technical Upgrades

1. Advanced Simulation Network
Purpose: To demonstrate the feasibility of upgrading SimLab host computers and Real-Time Network with newer and higher-performance systems.

2. Rotor Turbulence Model
Purpose: To create and implement a realistic rotor turbulence model for real-time motion simulations.

3. ESIG-3000 Test
Purpose: To determine the readiness of the newly integrated ESIG-3000 for a full-up production simulation at SimLab.

# SIMULATION PROJECTS




# HSCT-D 1

## GOALS:

The High Speed Civil Transport (HSCT) simulation investigated the development of advanced control and display systems for future large aircraft. (The HSCT is the United States' next generation supersonic transport aircraft.) This simulation experiment was the first of the collaborative efforts between Douglas Aircraft Company and NASA.

This program focused only on the longitudinal handling qualities. Under study were the location of the Center of Gravity (CG), the center of rotation (where the aircraft pivots during pitch), and time lags in the flight control computer (the delay from pilot input to aircraft response).

## Simulation Results:

Nine pilots flew a total of 884 data runs, using the motion system to perform the approach and landing tasks.

During the first week of the simulation, the Calspan pilot and engineer worked to precisely define the task on the simulator to conform with that flown on the USAF/Calspan Total In-Flight Simulator (TIFS) aircraft. Further evaluations were conducted with these configurations to determine the effects of longitudinal stability and vertical velocity damping, system transport delays, elevator control power and actuation rate, and longitudinal center of rotation, on control system design.

Three pilots from Ames, three from Douglas, and one each from Langley, Calspan, and the Air Force 4950th Test Wing participated in the experiment. Results covered handling characteristics that ranged from fully satisfactory to inadequate flying qualities. The industry participants found that the VMS facility provided an excellent capability to assess control and display design and flying qualities issues early in the design stage to determine impact on the aircraft configuration development.

Researchers have indicated that the simulation session was highly productive and generated a wealth of data for the Douglas Aircraft Company for future use in the development of control systems for the HSCT.

The data obtained from this simulation will be used to extend the results of flight experiments conducted by Douglas using TIFS. The experimental results are pertinent not only to the HSCT, but also to the planned Douglas MD-12 transport aircraft.

## Principal Investigators:

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## Simulation Project Engineers:

Robert H. Morrison
SYRE, a division of SYSCON Services, Inc.

Luong Nguyen
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### Technical Information

**Lab:** Vertical Motion Simulator
**Cab:** S-CAB
**Host Computer:** VAX 9000
**Visual System:** CT5A (Seymour-Johnson database)
**Head-Up Display:** IRIS10 computer
**Head-Down Display:** IRIS4, IRIS7, and IRIS8 computers

# HSCT-B 1

**GOALS:**

This simulation was considered a “shakedown simulation” since all of the required models were new. These included the aero model (developed mainly by the Boeing Company), the various control systems, the HUD, the HDDs, the flight management system, and the simple gear and engine models. This entry focused on collecting data to be used for evaluating and modifying the controls and displays for future simulations. The simulation had several long-term goals:

- determine viable control law concepts for HSCT,
- develop flying qualities criteria for HSCT,
- evaluate handling qualities with flexibility effects,
- determine the effects of synthetic vision on control laws,
- verify design integration of flight control and propulsion systems, and
- determine control surface sizing and actuation requirements.

Simulation operations were conducted for five weeks in I-CAB during August and September and one week in the VMS lab in November of 1993. Results from the fixed-base simulation and the motion-base simulation are included in this report.

## Simulation Results:

The basic pilot task consisted of flying the HSCT from an altitude of 1,500 feet along a “dog leg” that veered left to land. Most of the runs were done with slight winds and turbulence. Later in the simulation some pilots requested a zero visibility run (in the clouds to 100 ft. and in the dark) to verify the effectiveness of the HUD guidance. Typically, only one control system was studied during each pilot visit. After flying a particular control system, pilots were asked to evaluate detailed aspects of the approach, flare, and touchdown task.

A total of 474 data runs were completed. The models used in this simulation were developed mainly by the Boeing Company. Boeing and Ames each delivered three control systems. During the I-CAB simulation, three control systems were deemed mature enough to try in the VMS with motion. Three Ames pilots and a British Airways Concorde pilot took part in this entry. Though all the graphical displays were used, most of the comments were on the engine/flap display and the HUD. In general, the HUD received positive comments especially for the approach mode. The flight management panel was identified for improvement in the next simulation. Overall, the researchers were pleased to obtain useful flight control information in this preliminary simulation and to identify possible areas of improvement for the next simulation.

A second HSCT-B simulation was run in the VMS for further investigation and to build on information learned in this entry. For details on the next simulation see the HSCT-B 2 section later in this document.

## Special Requirements:

A flight management panel was built for this simulation that allowed the reference velocity, altitude, heading and course to be selected and then changed in flight.

## Principal Investigators:

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The Boeing Company

## Simulation Project Engineers:

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## Technical Information

**Lab:** Vertical Motion Simulator
**Cab:** S-CAB
**Host Computer:** VAX 9000
**Visual System:** DIG1
**Head-Up Display:** IRIS10 computer
**Head-Down Display:** IRIS4, IRIS7, and IRIS8 computers

# CTR4

## GOALS:

The Civil TiltRotor (CTR4) simulation was the fourth in a series of simulations. It is a joint NASA-FAA research project investigating aircraft certification, vertiport design, and terminal operations issues for tiltrotor aircraft.

The goal of the CTR4 experiment was to investigate certification requirements for civil transports operating to and from confined-space vertiports. Missed approaches were investigated, from a standard 9-degree approach developed during a previous fixed-base development session, and departure procedures were investigated. One Engine Inoperative (OEI), obstructions (vertiport traffic), and poor weather conditions were imposed at critical operating points to force pilots to make quick decisions and attempt to recover. Cockpit displays and other cockpit aids for approach and departure were also further developed.

An additional goal of this simulation was the continuous upgrading of the Generic TiltRotor Simulation (GTRS) model.

## Simulation Results:

The three objectives—preliminary evaluations of a 9-degree approach to an urban vertiport; evaluation of departure procedures, and updating the generic tiltrotor simulation math model used for real-time simulation—were successfully addressed. Pilot commentary, handling qualities ratings, and objective task measures were collected. Satisfactory handling qualities were reported although specific comments do point to desired improvements. Pilots also noted that improvements to cockpit automation and display assistance have made the level flight conversion task more manageable than in earlier simulations.

The approach and landing procedure was designed to take advantage of a tiltrotor's ability to perform a landing flare with nacelle angle (nacelles rotated upward) while maintaining a level fuselage attitude. This final configuration change for landing was acceptable to the airworthiness authority pilots, but it did raise training and "normal human pilot" reaction issues—pilots still tended to want to raise the nose some during the final landing maneuver. Several solutions to this problem were suggested: slow roll-on landings, more paved landing space on the approach side of the touchdown zone, a head-up display to continue landing guidance down very close to touchdown, or more contingency power to permit a slower final approach under Category A transport rules.

Another problem addressed during this simulation was how much performance margin is required in good, calm, test conditions to account for the effects of turbulence, poor visibility and cockpit distractions when responding to a departure engine failure. This research will continue in future projects. Also, researchers plan to upgrade the simulation to make it compatible with other models used in the industry. In this vein, the dynamics for the Civil TiltRotor will be implemented in place of the V-22 configuration.

## Principal Investigators:

William Decker
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Laura Iseler
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## Simulation Project Engineers:

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Norman Bengford
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### Technical Information

**Lab:** Vertical Motion Simulator
**Cab:** R-CAB
**Host Computer:** VAX 6000
**Visual System:** CT5A
**Head-Up Display:** n/a
**Head-Down Display:** IRIS8 computer

# ASTOVL-C

**Goals:**

The ASTOVL-C simulation was run fixed-base in the I-CAB lab. The aircraft simulated was a Short Take-Off/Vertical Landing (STOVL) supersonic fighter/attack aircraft. The aircraft used the Mixed Flow Vectored Thrust concept: hot and cold engine exhaust is directed downward or aft, for lift and cruise thrust respectively. The design incorporated both an Automatic Thrust Mode (ATM) where the pilot commands were interpreted by the flight control computer and adjusted thrust automatically, and a Full Thrust Mode (FTM) where engine thrust was directly controlled by the pilot.

The objectives of the simulation were as follows:

- evaluate direct thrust control with flight path velocity command augmentation during approach, and evaluate control conversions between approach modes and translational rate command (TRC), which is for vertical landing and take-off flight operations,
- evaluate the side stick control sensitivities in a STOVL attack/fighter, and
- evaluate the angular control margin display.

## Simulation Results:

Eight pilots flew a total of 166 data runs to evaluate the flying qualities of the aircraft in cruise, transition, and hover modes. All research objectives were achieved.

The test plan called for pilots to fly the aircraft by using ATM and FTM transition modes. Each mode enabled certain inceptors (cockpit controls), which the pilot could use to issue particular commands. The final aircraft performance evaluation required the pilot to use the chosen control inceptor modes and Head-Up Display (HUD) to perform the following tasks:

- slow landings,
- precision hover,
- decelerating transition to hover, and
- shipboard landings.

For all tasks the meteorological conditions (visibility, wind, turbulence, and/or sea state) were varied.

Preliminary results showed that during the first and second segments of shipboard approach and landing, there was little difference between FTM and ATM. There was a spread of Handling Qualities Ratings from Level 1, satisfactory without improvement, to Level 2, deficiencies warrant improvement, with respect to the weather and visibility conditions. The results on the third segment reaffirmed the desirable performance of the TRC in low speed flight operation. For the runway approach and vertical landing task, ATM's vertical speed command, which reduced pilot workload is definitely superior to FTM's direct thrust, which limited heave damper authority. However, in both configurations, the hover point capture was a two-handed task which undoubtedly increased pilot workload.

Information learned from this simulation was applied to the next entry in July and August of 1994. See ASTOVL-LF later in this document for more details.

## Principal Investigator:

William Chung
NASA/Ames Research Center

## Simulation Project Engineers:

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SYRE, a division of SYSCON Services, Inc.

Joseph Ogwell
SYRE, a division of SYSCON Services, Inc.

### Technical Information

**Lab:** I-CAB
**Cab:** F-CAB
**Host Computer:** VAX 6000
**Visual System:** CT5A
**Head-Up Display:** IRIS10 computer for FDI HUD
**Head-Down Display:** IRIS7 and IRIS8 computers

# HELMEE 2

## GOALS:

The Helicopter Maneuver Envelope Enhancement (HELMEE) 2 simulation developed insight into the issues associated with helicopter maneuver/control limiting and cueing.

With the use of fly-by-wire control systems, advanced control laws can reduce pilot awareness of proximity to control authority limits. A method of cueing the pilot to the remaining control margin must therefore be developed. Cueing may also allow pilots to make full use of the aircraft flight envelope with reduced workload.

The objectives of this simulation were to explore the potential of limit cueing for improving handling qualities, expanding the usable flight envelope, and reducing the incidence of exceeding aircraft limits.

## Simulation Results:

All researcher goals were achieved and over 1,200 data runs were collected. Besides the control case of having "no cues", fifteen different combinations of cues (non-linear control gradients, HUD symbology, voice warnings, and tones) were used for the evaluation. The relative benefits of these limit cues were evaluated for the performance of an air-to-air task and a turning autorotation task. Simulation results indicate that pilot workload for all tasks was higher when the cues were turned off. Cueing allowed for more aggressive tracking during the air-to-air task.

Also, no one cue was considered sufficient by itself. Combinations of cues were found to be more effective. Smarter cues were desired. For example, pilots should not have been cued for down collective if the collective was already all the way down.

Other specific findings follow:

- the collective stick force feedback was the most immediate and strongest cue,
- the HUD cue alone had little or no effect on task performance,
- the tone cue slightly improved task performance for the air-to-air task, but degraded the task performance for the turning autorotation,
- the voice cue degraded performance of the air-to-air task and had little or no effect on the turning autorotation task, and
- there was a demonstrated benefit to having multiple cues.

The challenge is to improve the logic to anticipate the circumstances under which pilots would want the cues to warn them. In addition, further cueing information to communicate the magnitude of required corrective control inputs would have been helpful. HelMEE 3, which is scheduled for FY95, will build on the results of this simulation by incorporating the lessons learned about limit cueing but with the addition of automatic SCAS limiting.

## Principal Investigator:

Matthew Whalley
U.S. Army Aeroflightdynamics Directorate (AVSCOM)

## Simulation Project Engineers:

Charles H. Perry Jr.
SYRE, a division of SYSCON Services, Inc.

Edward T. Fitzgerald
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### Technical Information

**Lab:** Vertical Motion Simulator
**Cab:** N-CAB
**Host Computer:** VAX 9000
**Visual System:** CT5A
**Head-Up Display:** IRIS9 computer
**Head-Down Display:** IRIS7 computer for terrain map, IRIS11 for lab instrument display

# CTR4.5 (ESIG-3000 TEST)

## GOALS:

The CTR4.5 simulation (and ESIG-3000 test) was a full-up simulation with researcher goals as well as SimLab goals. This was the first project to use SimLab's newest image generator—the Evans and Sutherland ESIG-3000. SimLab's primary goal was to "shakedown" the image generation system to verify its operational readiness.

The researcher's objectives were to familiarize pilots with the new visual system and solicit comments to evaluate flight path display modifications, and to create audio tones for "nacelle tilt" and "gear down". Most of the NASA pilots participated in the simulation, giving their first impressions of the new digital image generator and the newly created Bay Area database.

The SimLab objectives are discussed in the Technology Upgrades section of this document.

## Simulation Results:

Researcher's and SimLab's goals were achieved on this project. Pilot comments were highly favorable regarding the quality of the new visual system and the new Bay Area database. Several idiosyncrasies were discovered during the project, but SimLab personnel corrected or made recommendations for most issues.

More targets, special effects, and greater flexibility are available with the ESIG-3000. Also, it's texture capability is a significant improvement compared to the CT5A. The ESIG-3000's six channel display capability, a vast improvement over the CT5A, was especially useful during landing and hover tasks.

Pilot comments were favorable as to the realism of the images. Detailed texture, better display of lights and real scenery even from long distances, were welcomed by the pilots. Pilots commented that the visuals were easier on the eyes and therefore allowed them to fly longer.

In conclusion, the "shakedown" simulation was a resounding success. It verified the operational readiness of the new ESIG-3000 visual system. It also demonstrated to the customer that this visual system will provide considerably improved realism and fidelity to simulations at SimLab.

Additional database terrain maps will be created, in-house, and added to enhance the ESIG-3000 system. Refer to the ESIG-3000 Test (CTR4.5) discussion in the Technology Upgrade section of this document.

## Principal Investigator:

William Decker
NASA/Ames Research Center

## Simulation Project Engineers:

Joseph Ogwell
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Monique Chetelat
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### Technical Information

**Lab:** I-CAB
**Cab:** R-CAB
**Host Computer:** VAX 6000
**Visual System:** ESIG-3000
**Head-Up Display:** n/a
**Head-Down Display:** IRIS8 computer

# SSV-1

**GOALS:**

The Space Shuttle Vehicle (SSV) simulations are an ongoing part of the space program. Shuttle Orbiter landing and rollout studies are conducted twice a year at SimLab. This simulation was the first motion simulation to take advantage of SimLab's new Evans and Sutherland ESIG-3000 image generation system. The improved computer-generated image helps create a more realistic flight environment for the pilots.

The main objective of the shuttle simulation continues to focus on the effects of drag chute deployment. With information learned from previous drag chute landings, the profile of the drag chute force has been modified and incorporated into the Ames computers to more accurately simulate the real chute. This simulation studied the effects of drag chute deployment on handling qualities during the derotation and rollout phases.

Other issues under investigation included the following:

- study of a new tire wear model,

- effects of crosswinds, turbulence, and aerodynamic uncertainties on handling qualities (new wind profiles were included),
- modification and evaluation of Guidance Error Monitoring System (GEMS) (formerly called Pilot Assisted Landing, PAL), a proposed pilot performance monitor, to be used after extended duration flights,
- continuation of the Multifunction Electronic Displays (MEDs) study with several new displays under evaluation, and
- crew training and familiarization.

## Simulation Results:

The simulation was successful in meeting its goals. Researchers gathered data on gear loads and Handling Quality Ratings when deploying the drag chute at various velocities and vehicle weight/c.g. configurations to evaluate the trade-off between gear load reduction and vehicle handling qualities.

- A damp runway brake model was modified; significantly improved brake performance and brake feel.
- An improved tire wear model was incorporated into the simulation.
- An improved hybrid Autoland/Control Stick Steering (CSS) landing flight control system for Long Duration Orbit missions for GEMS was studied.
- The GEMS Head-Up Display characteristics were evaluated.
- An ongoing evaluation of Multi-function Electronic Display System (MEDS) glass cockpit displays in right seat was performed.
- 32 astronaut pilots performed Crew Training

Researchers' plans for future simulations include the following:

- Upgrade wind tunnel data with actual flight data as it becomes available,
- Gather data on gear loads and handling qualities when deploying drag chute at nominal velocities and vehicle weight/c.g. conditions,
- Incorporate anti-skid braking hardware into simulation,
- Incorporate and evaluate further refinements to GEMS,
- Perform ongoing evaluation of Multi-function Electronic Display System (MEDS) glass cockpit displays in right seat, and
- Perform ongoing crew training of astronaut pilots.

## Principal Investigators:

Howard Law
NASA Johnson Space Center

Viet Nguyen
Rockwell International

Mike Zyss
Rockwell International

## Simulation Project Engineers:

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### Technical Information

**Lab:** Vertical Motion Simulator
**Cab:** S-CAB
**Host Computer:** VAX 4000
**Visual System:** ESIG-3000
**Head-Up Display:** IRIS11
**Head-Down Display:** IRIS11, IRIS8, and IRIS9 computers

# CATAPOD

## Goals:

The goal of the Category A Terminal Area Procedure OEI (One Engine Inoperative) Display was to develop insight into the effectiveness of a panel mounted integrated display to assist transport rotorcraft pilots to perform Category A terminal area procedures. ("Category A" refers to the ability of an aircraft to withstand a major failure.)

The objectives of the study were as follows:

- determine the optimal flight paths for maximizing payload and safety while minimizing the heliport size, and
- determine the effects of fundamental parameters that govern the Category A operations.

For this simulation only engine failure emergency procedures were under study. Both a conventional instrument panel, typical of a Black Hawk helicopter, and an integrated display were examined. Researchers wanted to determine whether a pilot could reliably and repeatedly fly an arbitrary flight path in a helicopter by using the integrated display. The pilot's performance using the integrated display was compared to his performance using standard instruments.

## Simulation Results:

A total of 230 data runs were recorded and evaluated. Data was also taken with the project pilot to determine a first cut at the location of the Take-off Decision Point (TDP), the shape of the profile for the back-up task, and an appropriate power limitation to simulate civil rotorcraft OEI conditions. All researcher objectives were met.

Since the CATAPOD simulation was investigating the effectiveness of cockpit displays, several changes were suggested by the pilot staff during simulation operations. SimLab responded quickly to implement these changes, which included refining the various elements of the display: symbology, display laws, sensitivities, pilot strategy, and overall display function.

Pilots could fly both the straight and curved trajectories quite well with the display, but objected to the amount of pilot workload and the requirement for attention inside the cockpit. This problem may be alleviated with the development of a HUD. Flying in calm, clear conditions, pilots were able to fly the straight backup (or reverse) quite well. In degraded weather conditions, performance varied greatly for the visual task. Pilots who experienced the most trouble showed improved performance using the integrated display. Researchers think the display should provide the pilot with a clearer indication of what to do in the event of an engine failure. A better understanding of the benefits should be apparent when data analysis has been completed.

## Principal Investigators:

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## Simulation Project Engineers:

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Edward T. Fitzgerald
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### Technical Information

**Lab:** Vertical Motion Simulator
**Cab:** R-CAB
**Host Computer:** VAX 6000
**Visual System:** CT5A
**Head-Up Display:** n/a
**Head-Down Display:** IRIS9 computer


# GERMOU

## GOALS:

Under the U.S. / German Memorandum of Understanding (MOU) for cooperative research in helicopter aeromechanics, the Aeroflightdynamics Directorate, the U.S. Army Aviation and Troop Command (ATCOM), the German Institute of Flight Mechanics, and the German Aerospace Research Establishment (DLR) have been performing research in helicopter handling qualities.

The objectives of this VMS simulation were to develop a methodology to quantify the precise but aggressive small-amplitude slalom-tracking task in the frequency domain, and then define the relationship between the task frequency characterization and the rotorcraft response requirements (Bandwidth) for Level 1 and 2 handling qualities. Researchers hope to establish bandwidth requirements for other Mission Task Elements without extensive flight testing. The approach for this simulation was based on results and insights from previous roll-axis slalom studies and it took advantage of the complementary studies at the U.S., German, and UK ground-based and in-flight simulators.

## Simulation Results:

Two pilots performed over 500 runs. Preliminary results show a surprisingly good agreement in handling qualities ratings between the flight test results and the fixed-base results for the same control and rate coupling configurations. Each pilot flew one of the 21 slalom-tracking courses three to five times with feedback from the researcher of his gate score and performance of the altitude and airspeed minimum and maximum values. After the runs, the pilot then read through the Cooper/Harper handling qualities rating scale discussing each level while the researcher recorded remarks. For a given course, either the test configuration or the initial airspeed were changed after every rating.

The primary focus of this simulation was accomplished. A preliminary database to analyze and contribute toward an understanding of the issues and trade-offs between rotorcraft and task bandwidths was generated. In addition, the simulation provided data to aid in selecting courses and parameters for a DLR in-flight simulation in October 1994.

This simulation can be characterized as taking a very cursory evaluation over a broad range of configurations.

A more thorough in-flight simulation is planned for the summer of 1996.

## Principal Investigator:

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## Simulation Project Engineers:

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### Technical Information

**Lab:** Vertical Motion Simulator
**Cab:** R-CAB
**Host Computer:** VAX 4000
**Visual System:** CT5A
**Head-Up Display:** n/a
**Head-Down Display:** n/a


# SORBET

### GOALS:

The Simulation of Rotor Blade Element Turbulence (SORBET) project was a two-week simulation in the VMS. The purpose was to evaluate techniques for creating a realistic turbulence model for simulated rotorcraft.

The standard method of simulating turbulence is to assume a “fixed field”; that is, the aircraft is assumed to be moving through the air mass much faster than the rate at which the velocity of the air mass changes with time. For an aircraft that can hover in one place, this can sometimes produce results which do not simulate the effects of turbulence in a real aircraft.

For this simulation researchers looked at the math models of the rotor blades of a Black Hawk helicopter and divided each blade into several segments. A turbulence input was applied to each segment of each individual blade. The goal was to provide a realistic turbulence “feel” for the pilot in the simulation cab.

## Simulation Results:

During the two-week entry, approximately 200 runs were made. About half of these were for set-up, tuning, and providing baseline information. The other half were for data collection. The data runs included tasks such as hover and bob-up, descent to hover, and tracking a target aircraft through a Terrain-Following/Terrain-Avoidance (TFTA) style tunnel.

The investigators achieved their targeted goal. Pilot response was favorable. Most felt the blade element turbulence model was significantly more realistic than previous models.

Several simulations at SimLab will have the opportunity to use this turbulence model in the coming year.

For more information refer to the ROTOR TURBULENCE project in the Technical Upgrades section.

## Principal Investigators:

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## Simulation Project Engineers:

Soren LaForce
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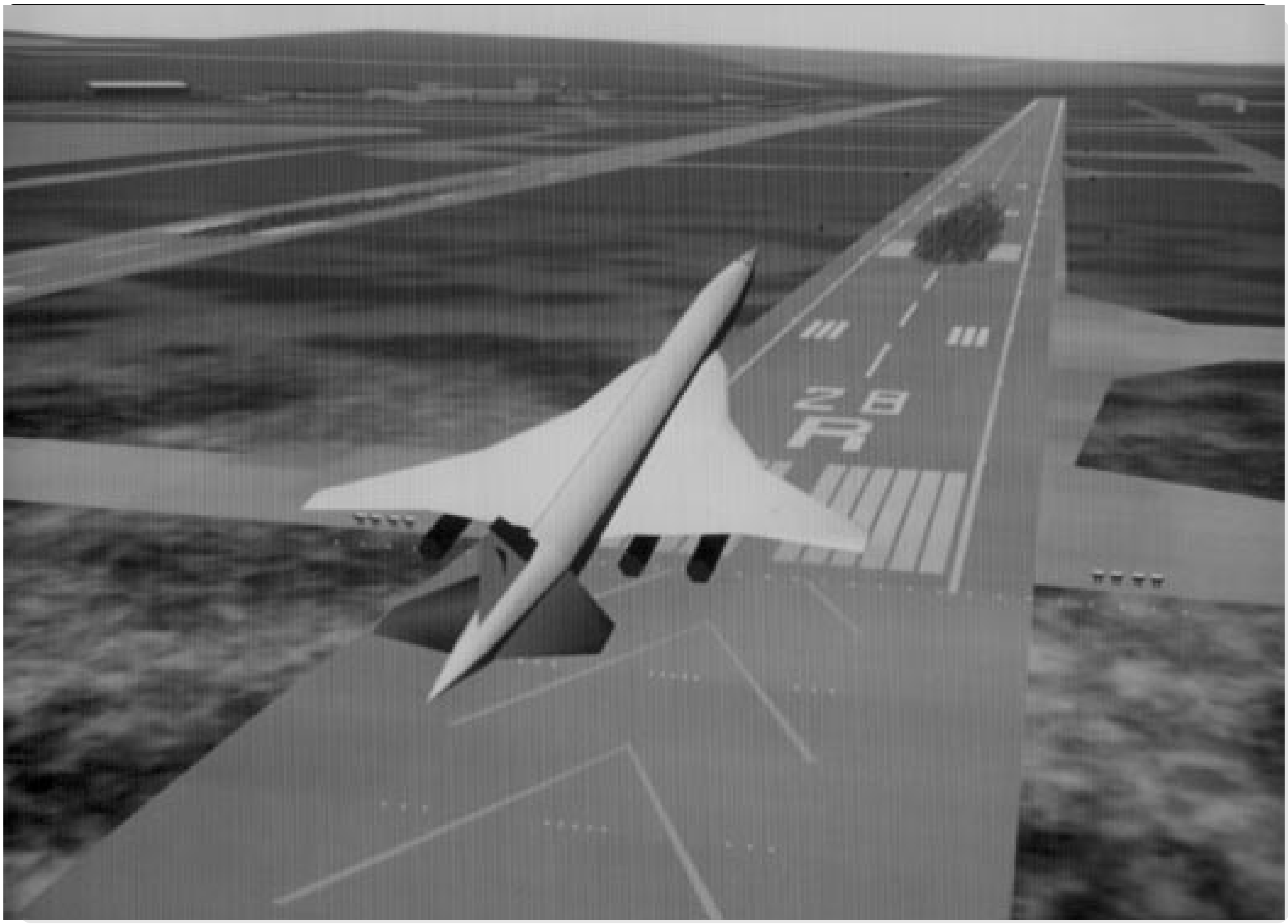
Duc Tran
NASA/Ames Research Center

### Technical Information

**Lab:** Vertical Motion Simulator
**Cab:** R-CAB
**Host Computer:** VAX 9000
**Visual System:** CT5A
**Head-Up Display:** IRIS8 computer for FDI HUD
**Head-Down Display:** IRIS10 computer




# HSCT-D 2

## GOALS:

The project was the second of two simulations in the VMS Lab as part of a collaborative effort between Douglas Aircraft Company and NASA/Ames Research Center. The goal of this High Speed Civil Transport-Douglas (HSCT-D 2) simulation was to investigate the flying qualities—during approach and landing—of two different aircraft; the HSCT and an augmented Generic Large Transport (GLT). The HSCT is a new generation passenger aircraft planned for the next century. It will fly at speeds of Mach 2.2 or more, with a fraction of the Concorde's engine emissions. The GLT is a subsonic transport, expected to reach Mach .85.

The objectives were to:

- develop control law design methods for the HSCT and the GLT,
- evaluate the longitudinal control modes for the GLT and the HSCT,
- examine the "back-side of the power curve" characteristics for the HSCT, including effects of the HUD, Direct Lift Control (DLC), and speed brakes,
- evaluate the new auto throttle design, and
- begin evaluations of lateral-directional flying qualities for the GLT.

## Simulation Results:

The researchers were successful in meeting all their project goals. Six pilots flew a total of 850 data runs, using the motion system, to perform the approach and landing tasks.

Some preliminary results for the VMS Lab session are summarized as follows:

- pilot ratings with the HUD were consistently one to two ratings better than without. All pilots were enthusiastic about the HUD's capability,
- pilot ratings were somewhat better than what the current MIL-SPEC predicts and the engine dynamics were better in this simulation,
- all pilots felt that the DLC, as implemented, had little effect; one pilot thought that it could be improved, and
- use of the speed brake to bring the vehicle on to the "frontside" after auto throttle failure was not preferred.

If it is given that the HSCT vehicle has (1) a drag versus speed curve like that examined (likely), (2) engine dynamics like that assumed in the model (somewhat fast), and (3) backside effects in tasks no worse than tested in the simulation experiment (maybe), then it appears that a full time auto throttle may not be required. A key experiment by NASA Langley will soon address this important engine dynamics issue.

## Principal Investigators:

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NASA/Ames Research Center

Ken F. Rossitto
Douglas Aircraft Corporation

Jeff D. Preston
Douglas Aircraft Corporation

## Simulation Project Engineers:

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## Technical Information

**Lab:** Vertical Motion Simulator
**Cab:** S-CAB
**Host Computer:** VAX 9000
**Visual System:** ESIG-3000 (SFO and San Francisco Bay Area database)
**Head-Up Display:** IRIS10 computer and two FDI HUDs
**Head-Down Display:** IRIS7, IRIS8, IRIS9 and IRIS11 computers

# HSCT-B 2

## GOALS:

The Boeing High Speed Civil Transport (HSCT-B 2) simulation was the second joint NASA/Boeing investigation aimed at preliminary control law development for supersonic transport aircraft.

The goals of this project were to refine and operationally extend the controls and displays of the aircraft based on information learned from the previous simulation. Specifically, the experiment:

- evaluated the flying qualities of three candidate control laws for the approach and landing task,
- investigated control law issues associated with the take-off and go-around tasks,
- assessed terminal area navigation features and additional enhancements of the Head-Up Display symbology, and
- compared manual landing performance in Category IIIB (CAT IIIB) conditions (50 ft. decision height, less than 700 ft. runway visual range) with automatic landing performance requirements.

### Simulation Results:

The goals for the simulation were achieved. A total of 1,023 data runs were completed. The researchers were satisfied with the quality and quantity of data they received. Some preliminary results included the Handling Qualities Ratings (HQRs) for the approach portion of each task and for the flare/touchdown/derotation portion of each task.

The HQRs for the approach portion of the tasks showed that the Boeing control system was preferred to the Ames control systems. This held true regardless of the wind/weather conditions. HQR's may be influenced by the HUD symbology which presents some information to the pilot differently between the Boeing and Ames control systems.

The HQRs for the Flare/TD/Derotate portion of the tasks showed the Ames control systems to be preferred over the Boeing control system. This was true for almost all wind/weather conditions. However, the worst wind/weather condition showed the ratings to be about the same between Boeing and Ames control systems.

### Special Requirements:

A request was made by the researcher to have the run number displayed on one of the lab monitors. This monitor was being recorded on tape. A Micro Character Generator (MCG) was used to provide this new capability for SimLab. Acquisition and integration of the MCG was accomplished in a limited amount of time.

### Principal Investigators:

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Charlie Hynes
NASA/Ames Research Center

George Lewis
Boeing

Greta Ward
Boeing

### Simulation Project Engineers:

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Charles H. Perry
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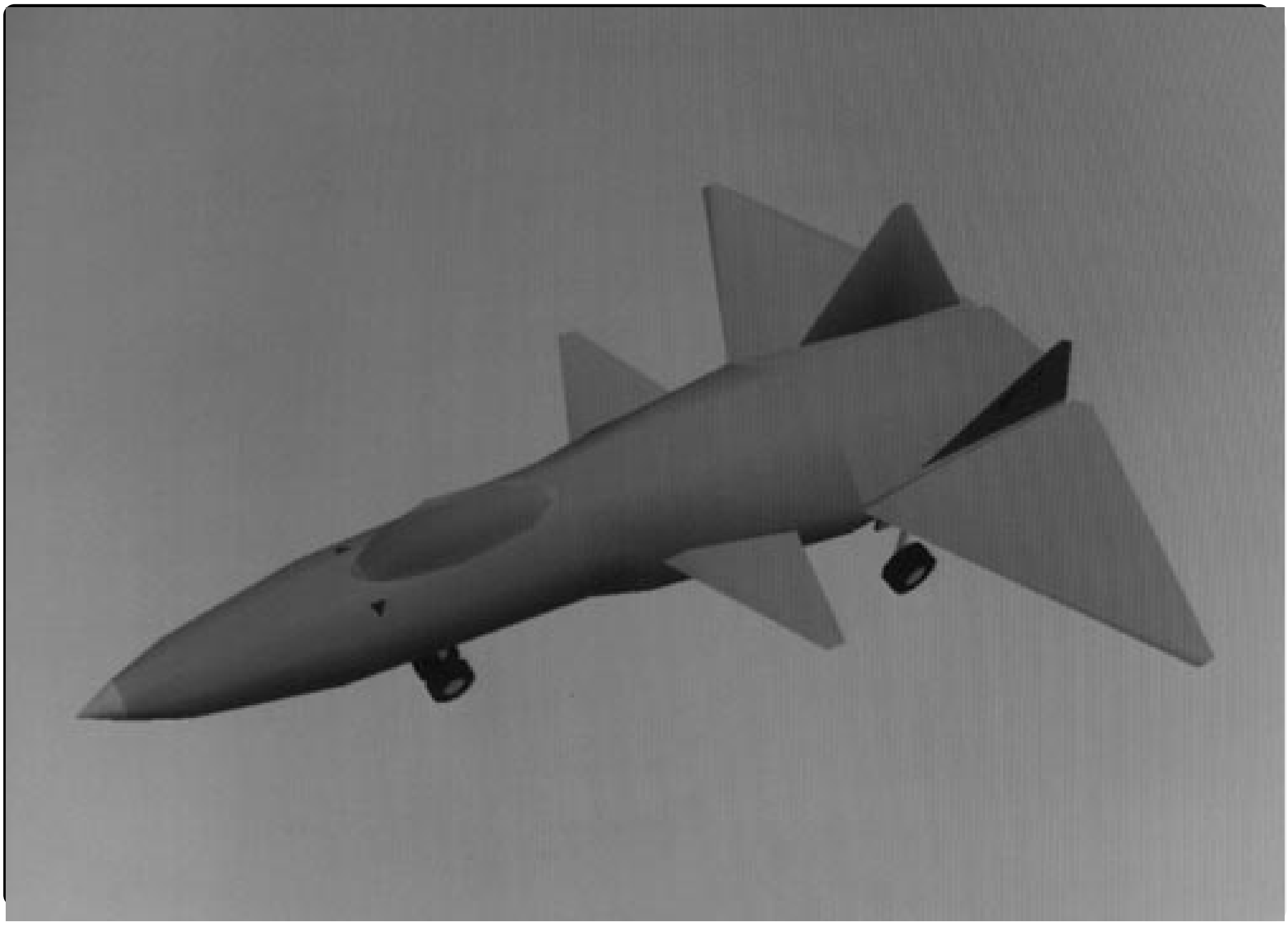
### Technical Information

**Lab:** Vertical Motion Simulator
**Cab:** S-CAB
**Host Computer:** VAX 9000
**Visual System:** ESIG-3000
**Head-Up Display:** IRIS10
**Head-Down Display:** IRIS7, IRIS8, and IRIS9computers



# ASTOVL-LF

### GOALS:

The Advanced Short Take-Off/Vertical Landing - Lift Fan (ASTOVL-LF) simulation was part of a United States effort to develop a jet fighter that will work for both land-based and ship-based operations.

There were three primary objectives for this flight simulation experiment:
- determine the influence of the propulsion system,
- evaluate the pilot/vehicle interface, and
- assess the flying qualities for operational tasks.

A generic ASTOVL aircraft math model was used. The propulsion system had four parts: a cruise nozzle, two lift nozzles, and an augmented lift fan which can be deflected in specified ranges. Researchers also evaluated the Ames-designed integrated flight/propulsion control system.

Two vertical landing tasks were to be performed: one was a shipboard landing, the other was a landing on a STOL (Short Take-Off and Landing) runway.

## Simulation Results:

Validation and tune-up operations were conducted during a three-week fixed-base session in I-CAB. Subsequently motion-base operations ran in VMS for five weeks. All of the researchers' goals were accomplished. Seven pilots flew a total of 264 data runs to evaluate the flying qualities of the aircraft in cruise, transition, and hover modes. In addition, flight test engineers from Boeing, Lockheed, NATC and RAF flew familiarization runs.

According to researchers, "the VMS simulation is the first effort by the government to evaluate the lift fan performance criteria for the Advanced STOVL fighter aircraft." The experiment also studied the control mode transition, pilot/cockpit interface, and the performance of the integrated flight/propulsion control system.

The preliminary data indicates that the lift fan and core engine response characteristics were consistent with those required to provide desirable handling qualities in a shipboard landing task. The data also shows the roll control power required to maintain the station point capture exceeds the requirements of MIL-F-83300. For most approach and station-keeping point acquisition tasks, Level I handling qualities were achieved. For vertical landing on the ship, the pilot ratings were between Level I and II.

## Principal Investigators:

William Chung
NASA/Ames Research Center

Paul Borchers
NASA/Ames Research Center

Lourdes Birckelbaw
NASA/Ames Research Center

Jack Franklin
NASA/Ames Research Center

## Simulation Project Engineers:

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Duc Tran
NASA/Ames Research Center

### Technical Information

**Lab:** Vertical Motion Simulator
**Cab:** F-CAB
**Host Computer:** VAX 6000
**Visual System:** CT5A
**Head-Up Display:** IRIS10 computer
**Head-Down Display:** IRIS7 and IRIS8 computers


# SSV-2

**Goals:**

This Space Shuttle Orbiter experiment in the Vertical Motion Simulator (VMS) concentrated on the lateral (or side-to-side) handling qualities of the Orbiter on the runway, guidance improvements during landing, and astronaut training.

One area of study was the use of high speed differential braking for lateral control on the runway. The shuttle braking system includes an "anti-skid box", which is similar to anti-lock brakes in an automobile. The effects of the anti-skid box when braking at high speeds were unknown and were studied during this simulation.

Guidance improvements during the Terminal Area Energy Management (TAEM) flight regime were investigated, and three weeks of the simulation were devoted to astronaut training.

## Simulation Results:

A total of 1,696 data runs were completed. Preliminary results indicate that the proposed TAEM guidance improvements greatly improved the performance of the guidance system; however, further work is required to ensure stability. Some preliminary recommendations have been made in an effort to improve the lateral handling qualities of the Orbiter.

The crew familiarization phase reinforced the importance of the VMS in preparing upcoming crews for the landing and rollout phase of the mission and for possible failures during that phase. Additionally, the VMS was found to be valuable in training for the proposed Detailed Test Objectives (DTOs) established by the Johnson Space Center for the orbiter.

## Special Requirements

This was the first simulation in seven years to use the antiskid box. After the box was delivered to SimLab, it was cabled, integrated, calibrated, and made available for simulation use within two weeks. In order to use the antiskid box, a substantial effort was spent to resequence the simulation code to run twice as fast as it did in the past. To minimize delays into and out of the box, SimLab personnel designed a circuit to take the signal directly from the rudder pedals to the antiskid box.

## Principal Investigators:

Howard Law
NASA Johnson Space Center

Viet Nguyen
Rockwell International

David Mains
RSOC

## Simulation Project Engineers:

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Ken Duisenberg
SYRE, a division of SYSCON Services, Inc.

Bob Gardner
NASA/Ames Research Center

## Technical Information

**Lab:** Vertical Motion Simulator
**Cab:** S-CAB
**Host Computer:** VAX 4000
**Visual System:** ESIG-3000
**Head-Up Display:** IRIS11 computer
**Head-Down Display:** IRIS7, IRIS8, and IRIS9 computers

# BLIMP

## GOALS:

The goal of the Blimp Simulation was to evaluate the handling qualities of an airship, the YEZ-2A, during refueling and resupply from a surface ship under VFR conditions at a number of airspeeds and static heaviness. (Heaviness was defined as the difference between weight and buoyancy.) The additional objective was to evaluate three Head-Down Displays (HDDs).

The tasks were evaluated with and without systems failures. System failures included: failure of one or more of the four engines, failure of one or more control surfaces, and engine fires. Handling qualities were also evaluated with and without the auto-throttle system that controls height-above-ground with the main engines. The use of the auto-throttle reduces the pilot workload.

The YEZ-2A is of recent design and incorporates several features not found in more conventional lighter-than-air craft. For example, the envelope and much of the structure are made using composite materials. In addition, the airship will incorporate a fly-by-light control system.

### Simulation Results:

Approximately 170 runs were completed. Most runs lasted 30 to 45 minutes. All simulation objectives were successfully accomplished. The Westinghouse Airship, Inc. and Westinghouse Surveillance Systems, Ltd. personnel indicated that they were extremely satisfied with the support, operation, and results of the simulation.

One of the simulation goals was the evaluation of three HDDs similar to display "pages" intended for use in the YEZ-2A. A fourth HDD was developed and implemented after the start of the simulation. This display resulted from information gained from the initial use of the original displays.

The utility of the YEZ-2A for the intended tasks was determined. This was particularly critical, as one of the main goals was to demonstrate that under adverse conditions (e.g. heavy airship combined with loss of engine and/or control surface) the airship would be able to avoid both collision with the surface ship and contact with the sea. Both of the criteria were met without difficulty.

All six displays (windows) of the ESIG-3000 were used for this simulation. The six-window capability allowed for a four-monitor view in the cockpit, a view from the refueling bay of the airship, and a view for the researchers to observe the airship from the VMS lab, during piloted operations.

### Principal Investigators:

Chuck Klusmann
Westinghouse Airships Incorporated

Dave Speirits
Westinghouse Surveillance Systems Limited

### Simulation Project Engineers:

Soren LaForce
SYRE, a division of SYSCON Services, Inc.

Edward T. Fitzgerald
SYRE, a division of SYSCON Services, Inc.

*This project started in FY94 and was completed in FY95.

### Technical Information

**Lab:** Vertical Motion Simulator
**Cab:** N-CAB
**Host Computer:** VAX 9000
**Visual System:** ESIG-3000
**Head-Up Display:** n/a
**Head-Down Display:** IRIS9, IRIS10, and IRIS11 computers

# TECHNOLOGY UPGRADES

# ADVANCED SIMULATION NETWORK PROJECT (ASN)

## GOALS:

The Advanced Simulator Network Project (known as the ALPHA Project) was an investigation to demonstrate the feasibility of upgrading SimLab host computers and Real-Time Network with newer and higher-performance systems. The project seeks to provide better performance while retaining the powerful functionality of the current system. Another objective is to integrate the new system in such a manner as to minimize interference with operational simulations.

The overall project has two separate phases: a prototype phase and an integration phase. The prototype phase, consisting of proving the design through the acquisition, integration, and successful testing of a prototype system, was the primary focus during FY94.

## Results:

The prototype system hardware was acquired and the simulation executive software from the currently used hosts was ported to a Digital Equipment, Corp. ALPHA AXP workstation host. Tests of the prototype system confirmed that the functionality of the current system was carried over, and that the performance expectations were met.

In preparation for the "integration phase", preliminary maintenance and operations plans have been prepared. The first simulation facilities to be integrated are a fixed-base lab and a cab outfitted for evaluation of the new system. Integration with the Vertical Motion Simulator and remaining fixed-base facilities and cabs is scheduled for FY95-96.

## Principal Investigators:

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Carla Ingram
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Steve Belsley
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# ROTOR TURBULENCE MODEL

## GOALS:

This project was undertaken to create a realistic turbulence model for motion simulation of a helicopter. Prior to this project, simulated rotorcraft utilized the same turbulence used for fixed-wing aircraft. Pilots commented that the resulting motion was not representative of that felt in an actual helicopter. To address these comments, a turbulence model was designed specifically for rotating blades. Like fixed-wing turbulence models, this model maintains a foundation in atmospheric physics, and it can be easily integrated into many of the helicopter simulations at SimLab.

## Simulation Results:

The new rotor turbulence model was the main focus of investigation during the SORBET simulation on the VMS in May 1994. The efficient implementation of the model added less than 10% to the required computer cycle time and proved that real-time blade element turbulence models are now feasible. Ten pilots flew with both the fixed-wing and the rotor turbulence models. They all agreed that the new rotor turbulence model provides an improvement in realism. They especially favored the nonlinear effects, such as variable turbulence amplitudes, patches of calm air, and vertical gusts. Based on pilot comments, the model was refined and enhanced for general use.

Several simulations will have the opportunity to use the new turbulence model in the coming year. The model's concept, investigation and results will also be published as a NASA-TM and be presented in an AGARD conference during FY95.

## Principal Investigators:

Richard McFarland
NASA/Ames Research Center

Ken Duisenberg
SYRE, a division of SYSCON Services, Inc.

# ESIG-3000 TEST (CTR4.5)

## GOALS:

The primary objective of the ESIG-3000 test (CTR4.5 simulation) was to determine SimLab's readiness to utilize the newly integrated ESIG-3000 in a full-up production simulation environment. CTR4.5 was a natural extension of the recently completed CTR4 production simulation. ESIG integration project objectives included the following:

- operation from multiple hosts, test and evaluation of network and display system interfaces,
- quantification of Image Generation (IG) transport delay characteristics,
- first use of a database developed entirely in-house, and
- test operational procedures.

## SIMULATION RESULTS:

The research team was able to collect valid test data on terminal area operations procedures. In addition, the research team was able to test and evaluate several iterations of texture and feature modifications to the newly created CTR4.5 database.

The ESIG-3000 was operated successfully from all primary simulation hosts utilizing several configurations of real-time network resources. This was the first time that the primary Out-the-Window (OTW) IG had been operated using SimLab's real-time Ethernet network. The CTR4.5 database featured multiple basis-set texture models, terrain feature, and cultural models for the City of San Francisco, Treasure Island Naval Air Station, major bridges, and the China Basin Vertiport, which were developed and/or modified in-house to meet simulation objectives. CTR4.5 utilized four OTW displays in the cockpit. An additional ESIG channel was used to generate a "Bird's Eye View" of the aircraft for lab observation and recording. ESIG transport delay characteristics were also quantified and validated in separate testing.

The ESIG-3000 acceptance test simulation was a great success. It provided validation of SimLab's capacity to provide an end-to-end solution for acquisition, test and operation of a new, state-of-the-art visual flight simulation resource.

The ESIG-3000 is fully integrated and operational. Future plans include: an extensive database modeling effort to support new and existing simulations, possible IG upgrades to advanced texture and fast jet collision detection, upgrade of existing database modeling capabilities, acquisition of additional database modeling capabilities and development of ESIG real-time code modification capabilities.

## PRINCIPALS:

ESIG-3000 Integration Team
a joint SYRE/NASA endeavor at SimLab

## NOTES:

## Notes:

For additional information, please conctact

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